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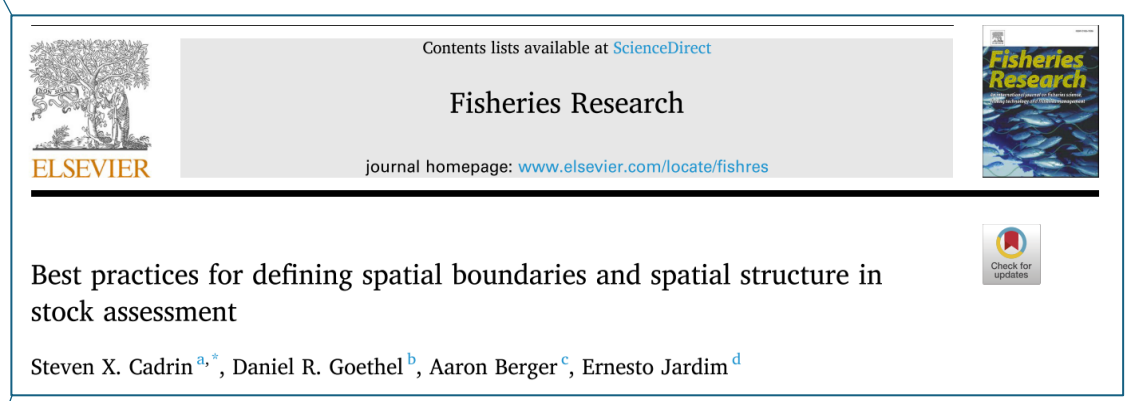
Review of the stock structure of yellowfin tuna in the Indian Ocean: facts and gaps

Iraide Artetxe-Arrate, Igaratza Fraile, Patricia Lastra-Luque, Giancarlo Morón Correa, Agurtzane Urtizberea, Natalia Diaz-Arce, Gorka Merino and Iker Zudaire.

Stock structure in stock assessment

1. Interdisciplinary stock identification to delineate spatially discrete populations or more complex population structure
2. Stock boundaries that are aligned with the most plausible population structure
3. Spatially-explicit sampling, fleet structure or spatial structure in assessment models to account for heterogeneity, fishing patterns, and movement within stock areas
4. Routine stock composition sampling and analysis for spatially overlapping populations
5. Simulation testing the performance of assessments with mis-specified or uncertain population structure



Contents lists available at ScienceDirect

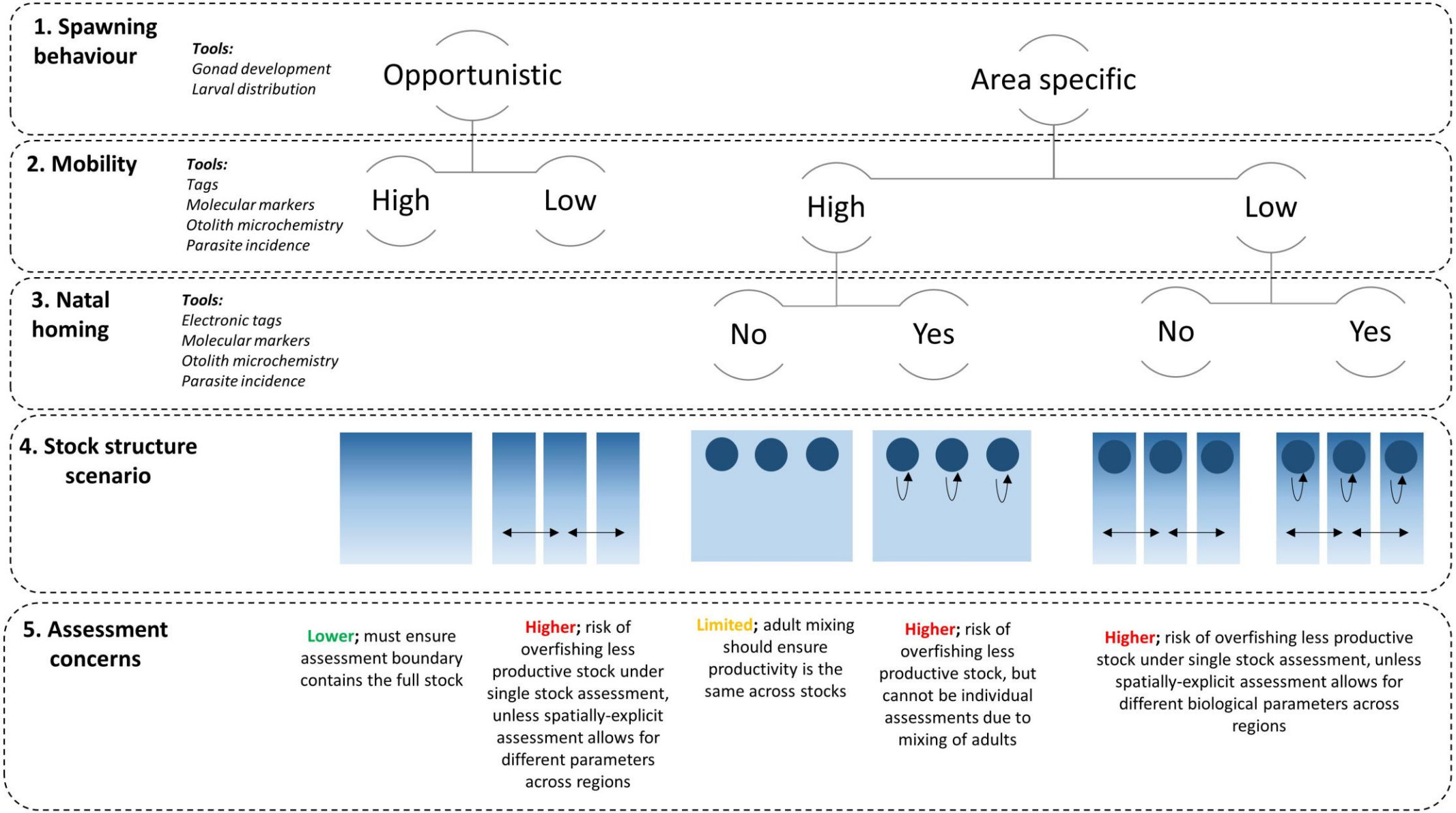
Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Best practices for defining spatial boundaries and spatial structure in stock assessment

Steven X. Cadrin [a,*], Daniel R. Goethel [b], Aaron Berger [c], Ernesto Jardim [d]

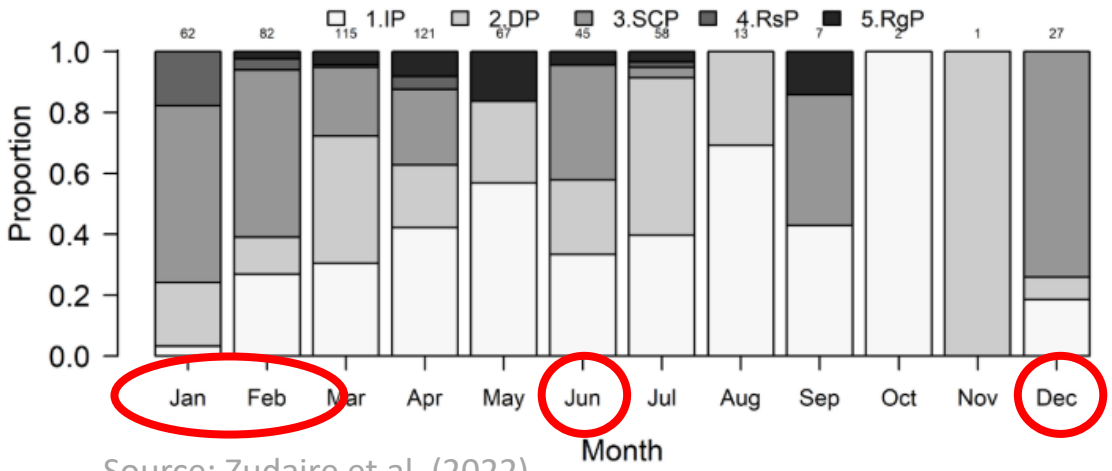
Stock Structure Scenarios



Source: Artetxe-Arrate et al. 2021; Adaptation from SPC FAME, 2019.

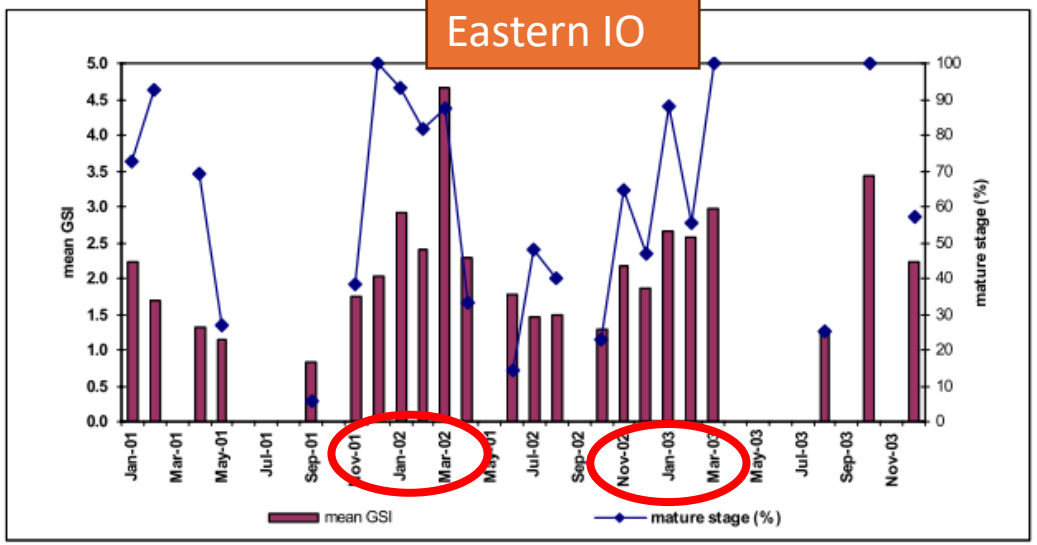
Spawning behaviour

Western IO



Source: Zudaire et al. (2022)

Eastern IO



Source: Nootmorn et al. (2005)

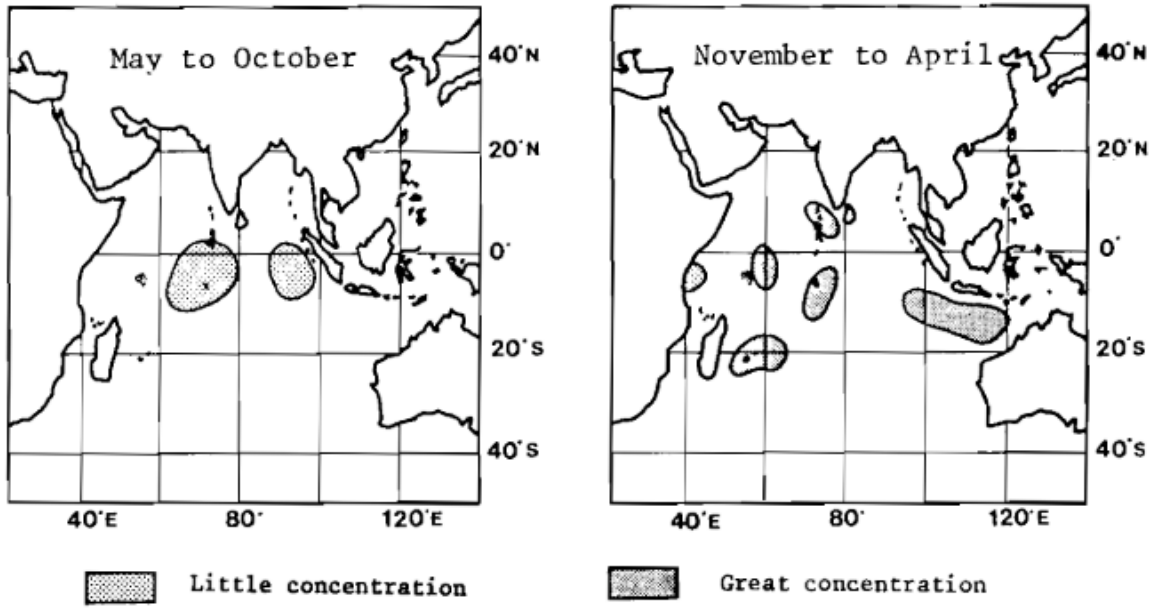
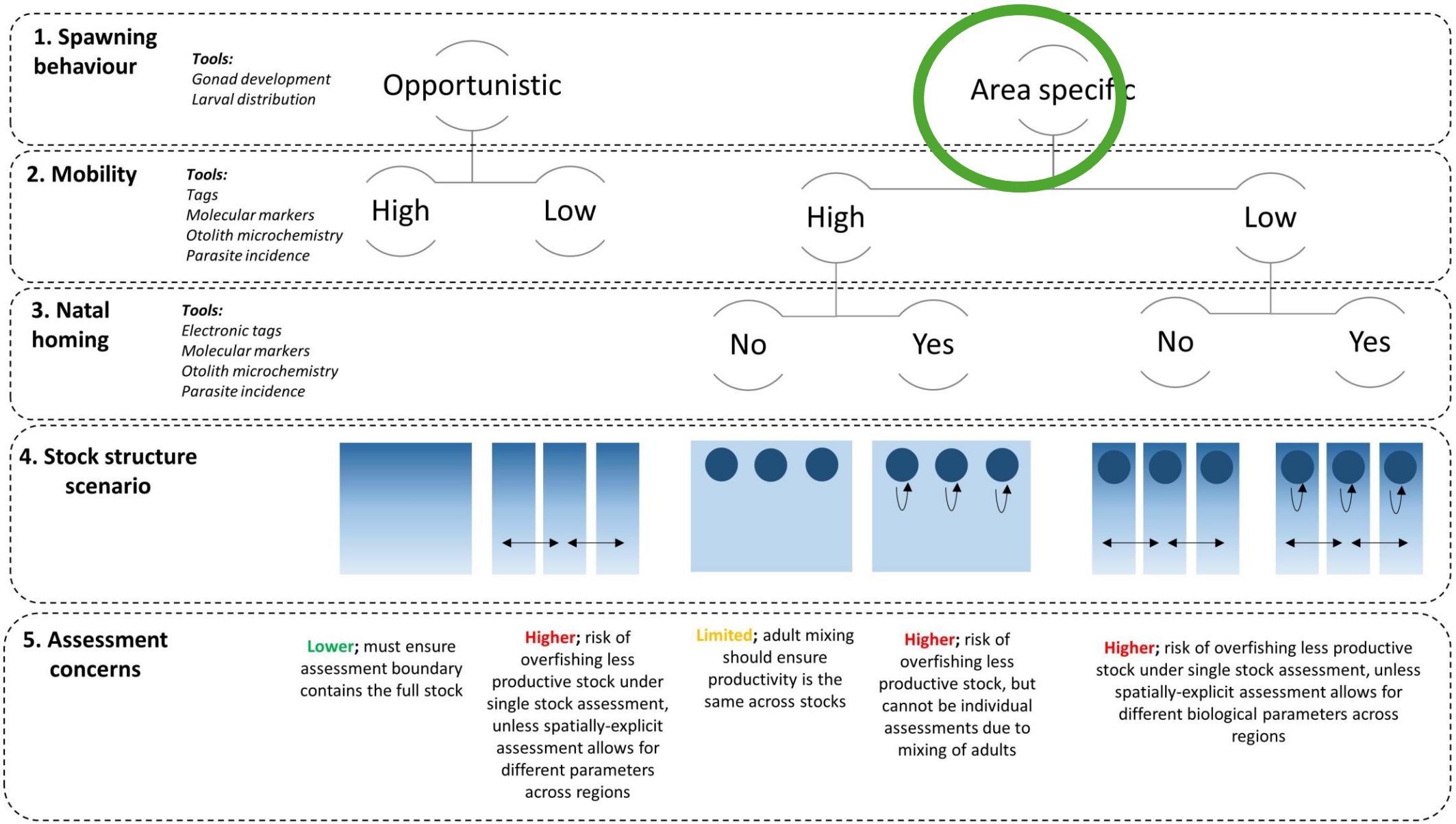


Figure 11. Distribution of yellowfin larvae (Ueyanagi, 1969)

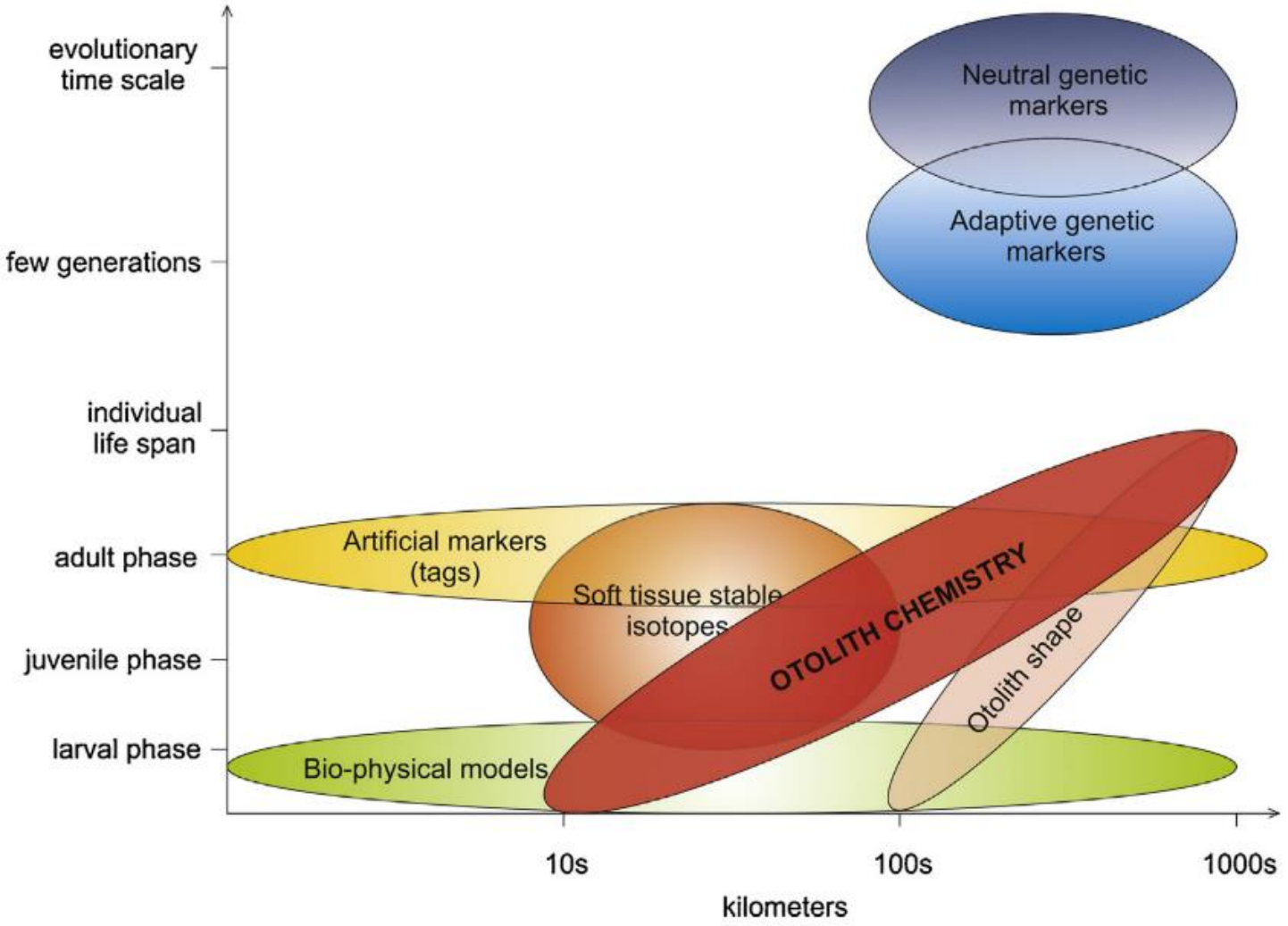
Source: Stequert & Marsac (1989)

Stock Structure Scenarios



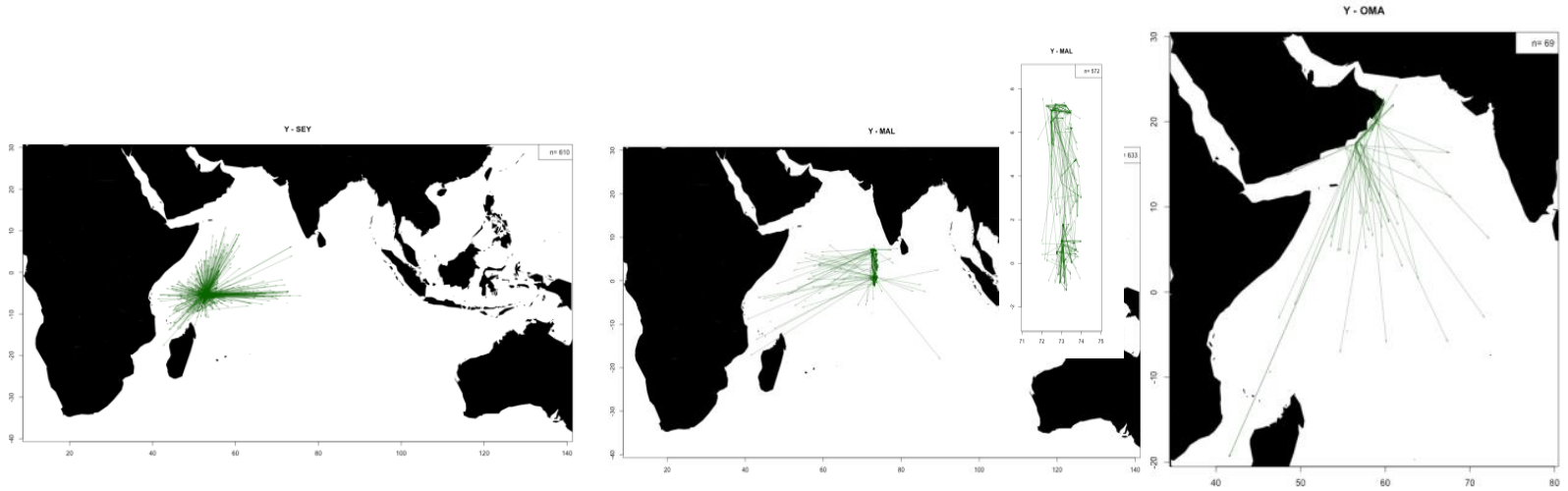
Source: Artetxe-Arrate et al. 2021; Adaptation from SPC FAME, 2019.

Stock structure delineation methods

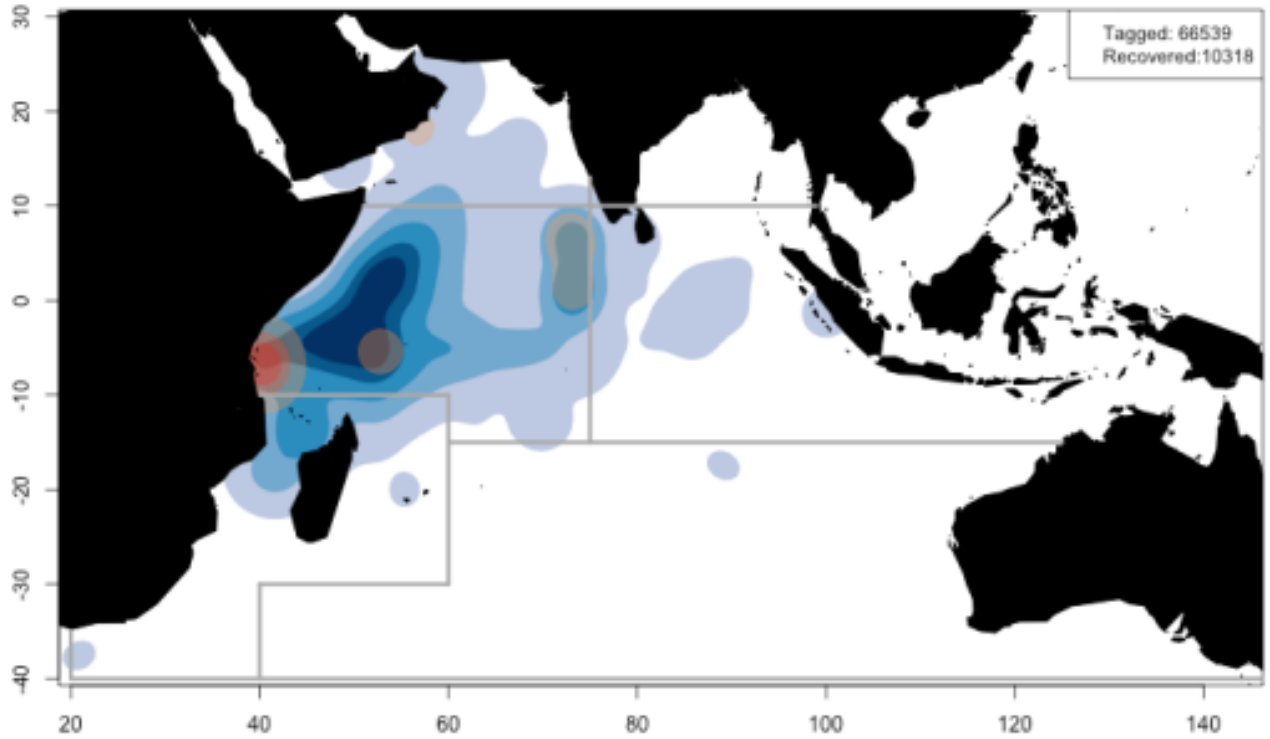


Source: Tanner et al. 2016

Tagging



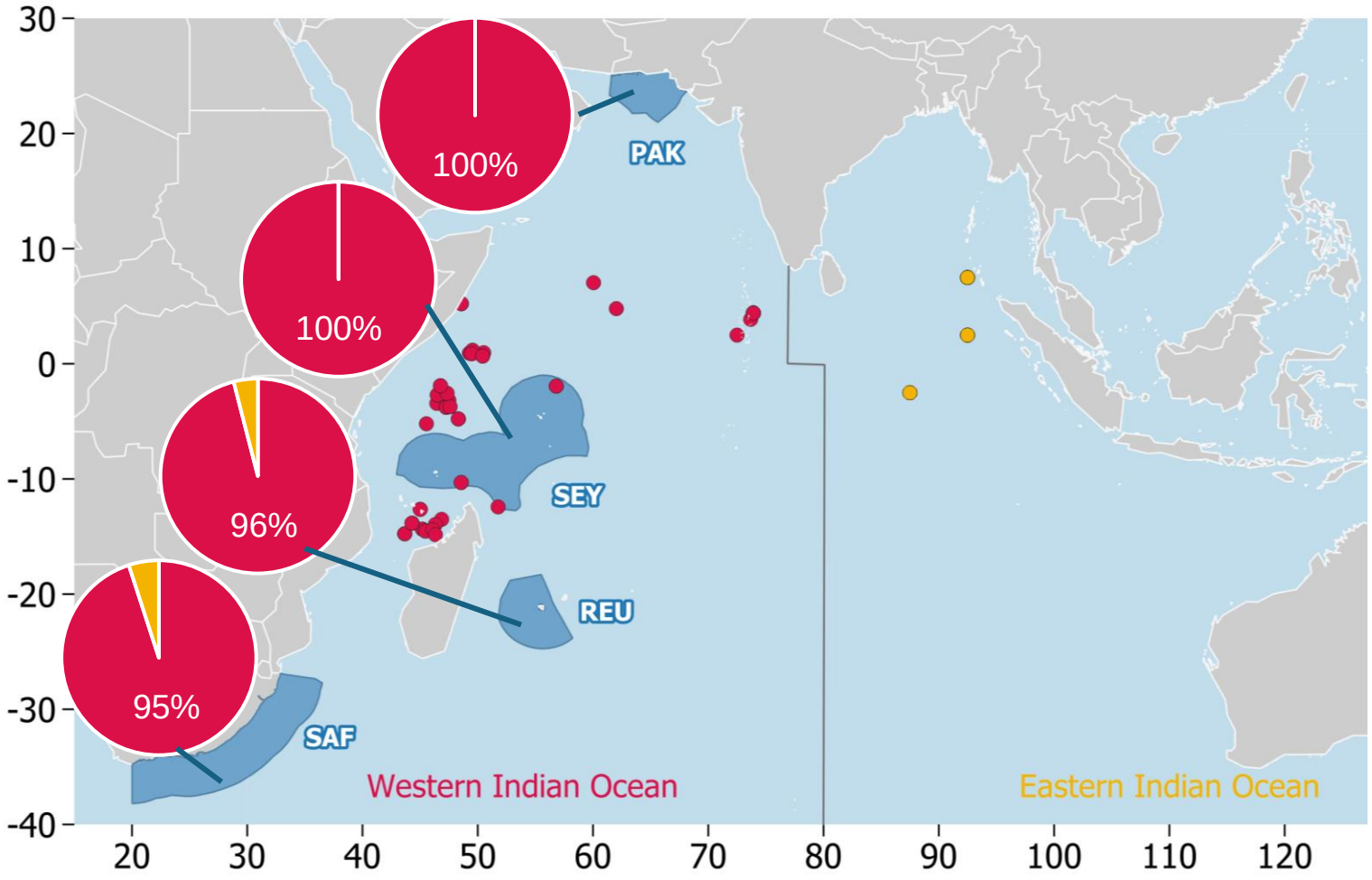
- RTTP-IO provided evidence of fast and **large-scale movements**
- Connectivity between central and western IO
- Retention in some areas (e.g. Maldives)
- Most tagging events in the western IO, few recoveries in the east
- Unclear if this finding reflects low rates of movement between yellowfin tuna of the western and eastern Indian Ocean, or if it is an artifact of low reporting rates from fisheries operating in the eastern Indian Ocean



Source: Hallier and Million, 2012

Otolith chemistry

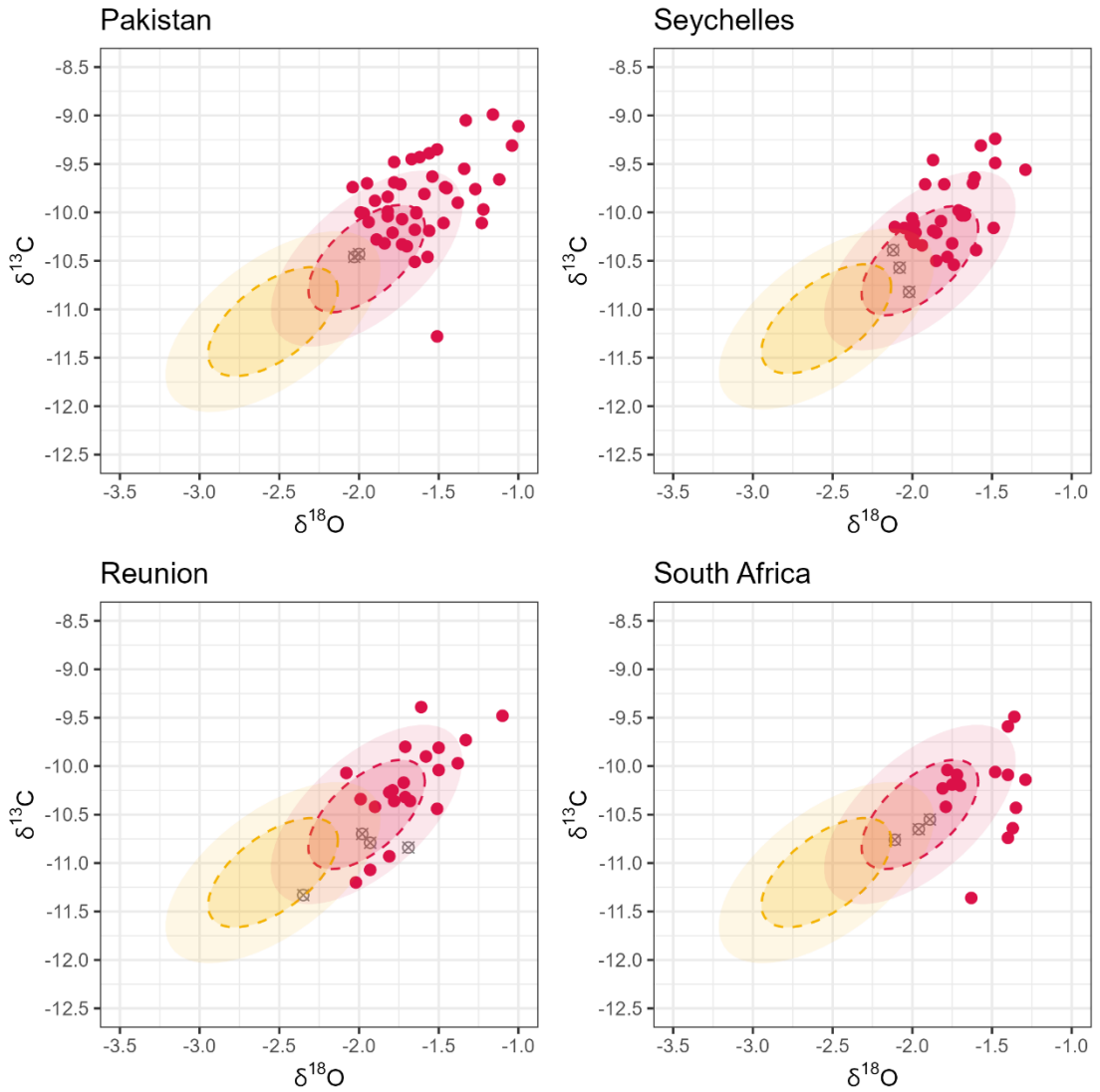
- Western Indian Ocean fisheries are mainly composed of western origin fish



Source: Artetxe-Arrate et al. *Submitted*

Otolith chemistry

- Western Indian Ocean fisheries are mainly composed of western origin fish
- But there were some individuals with an otolith isotopic signature that was not characteristic of either of the samples available in the baseline
  - Spatial component?
  - Temporal component?



Source: Artetxe-Arrate et al. *Submitted*

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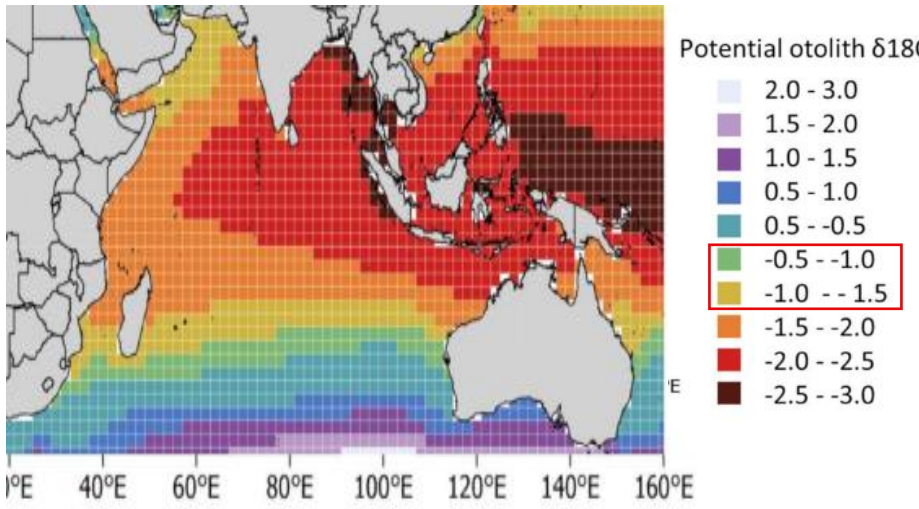
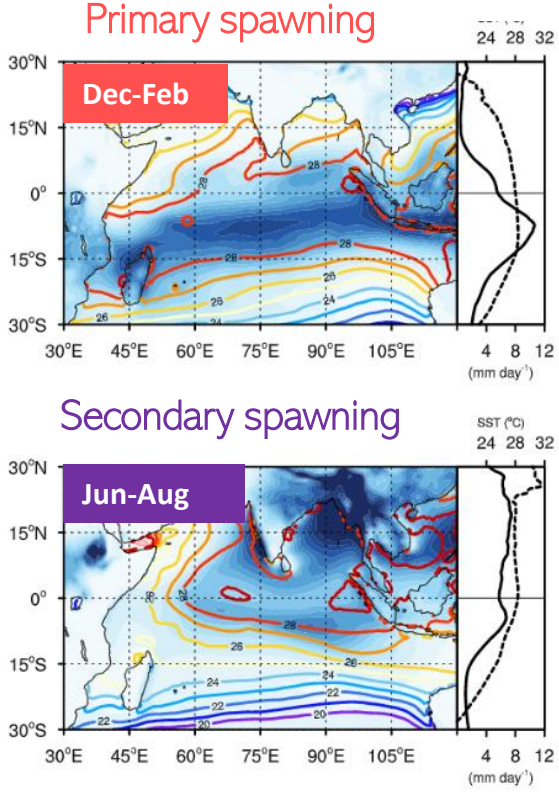


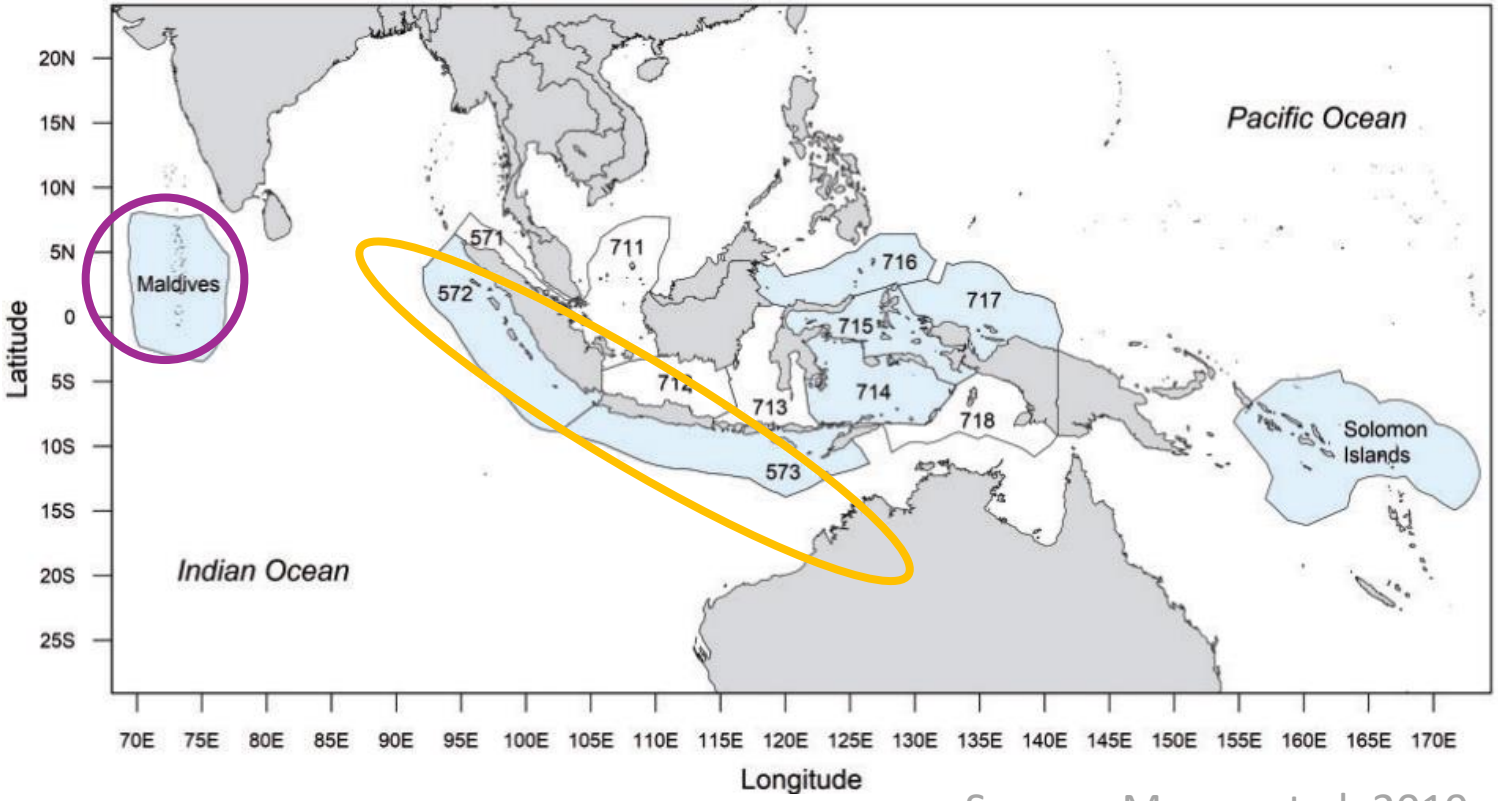
Source: Artetxe-Arrate et al. 2021



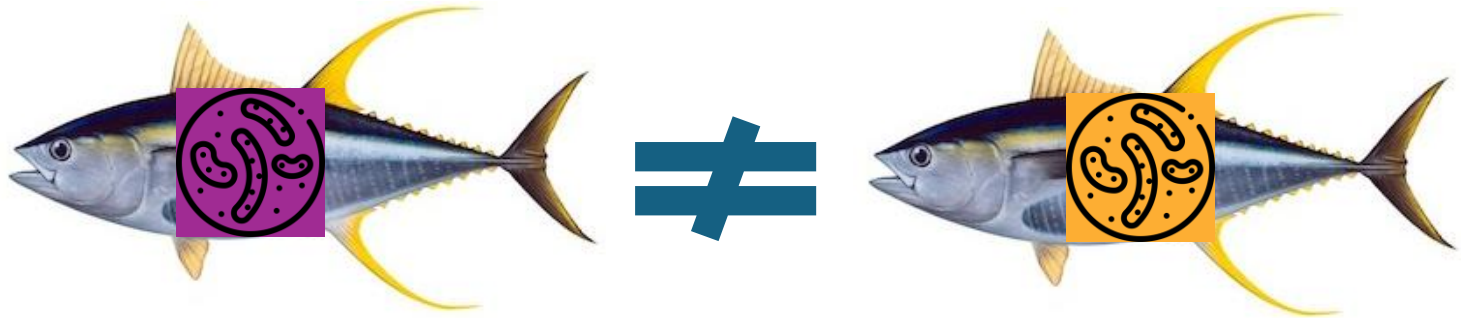
Source: Keshtgar et al., 2020

Parasite data

- Different parasite composition between yellowfin tuna from the Maldives and Indonesian EEZ
- Limited movements from Maldives to the east
- Limited movements within the Indonesian archipelago to the eastern Indian Ocean



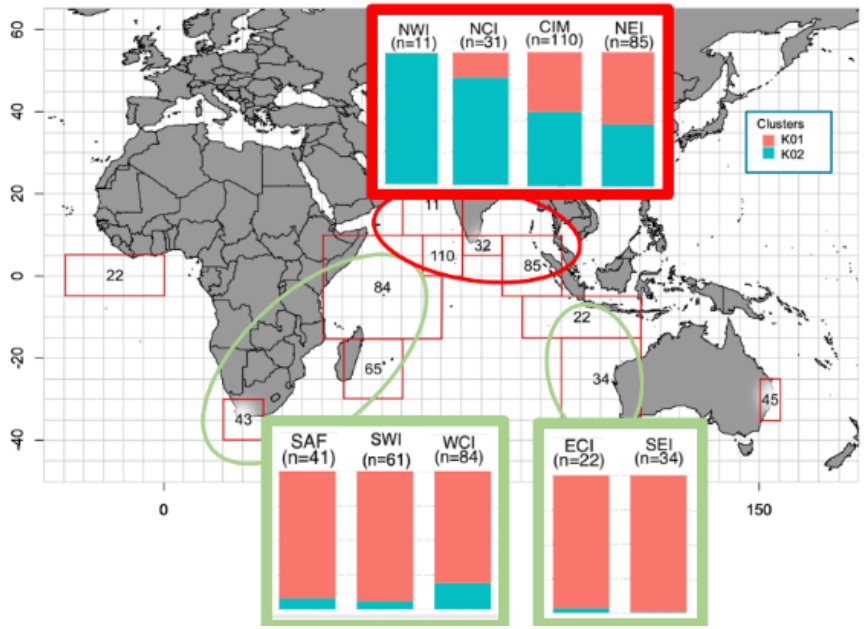
Source: Moore et al. 2019

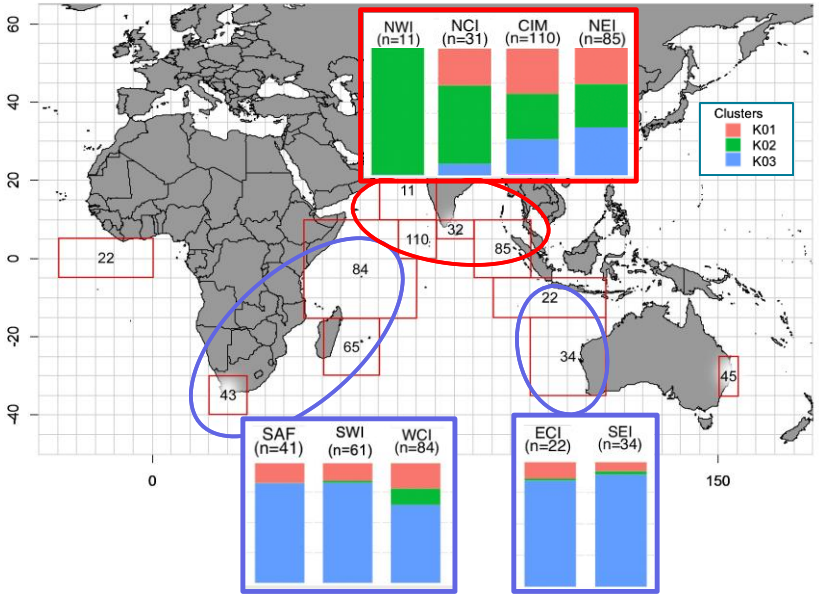


Maldives ≠ Indonesia EEZ

Genetics

- Minimum of 2 genetically differentiated groups of yellowfin tuna (but likely more) with different contribution north and south of the equator (Grewe et al. 2020)



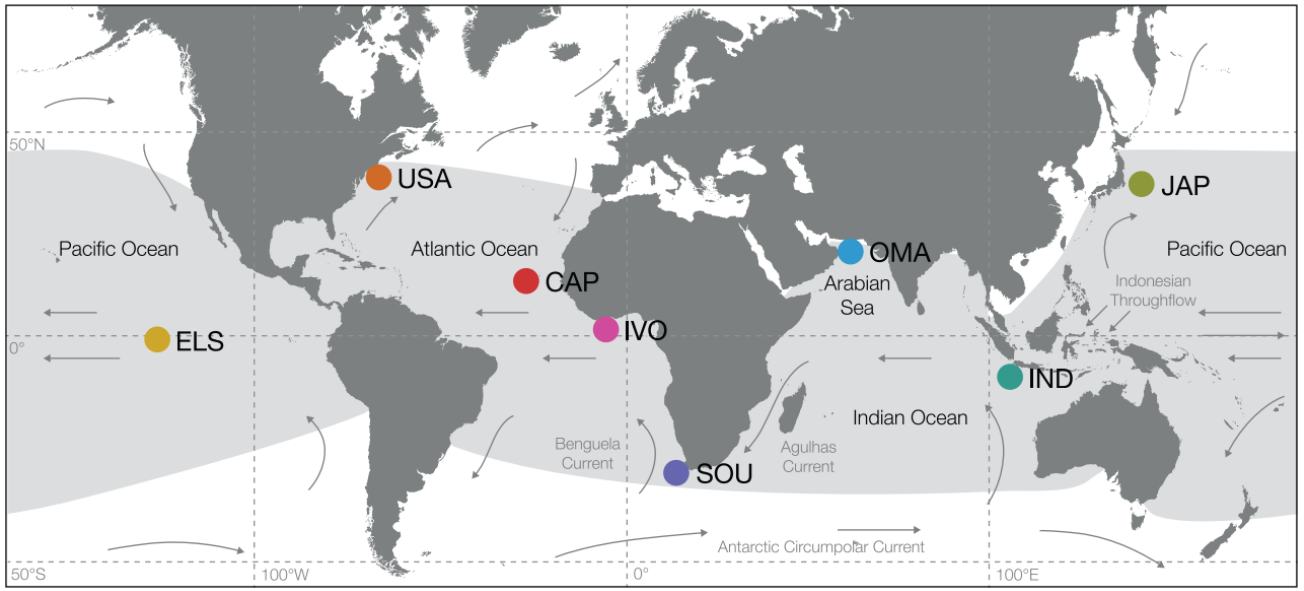


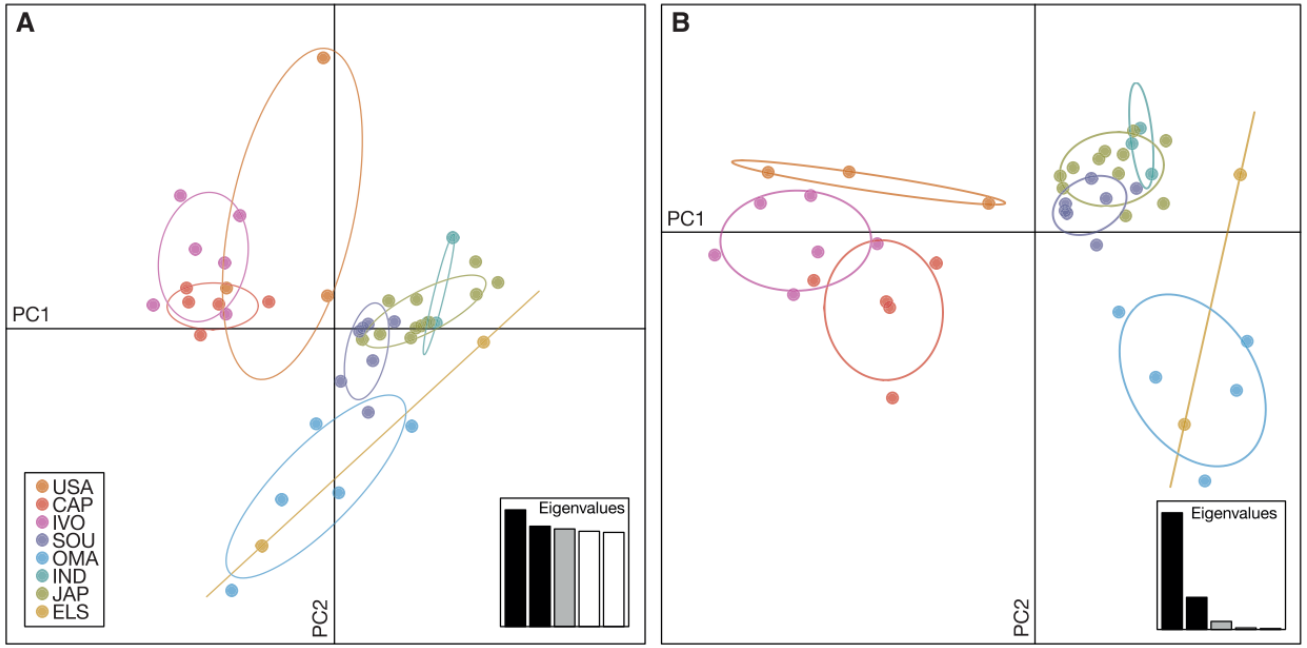
Source: Grewe et al. 2020

Genetics

- Minimum of 2 genetically differentiated groups of yellowfin tuna (but likely more) with different contribution north and south of the equator (Grewe et al. 2020)

- Genetic differentiation of yellowfin tuna from the Arabian Sea compared to those from the Atlantic and Indo-Pacific oceans (Barth et al. 2017)

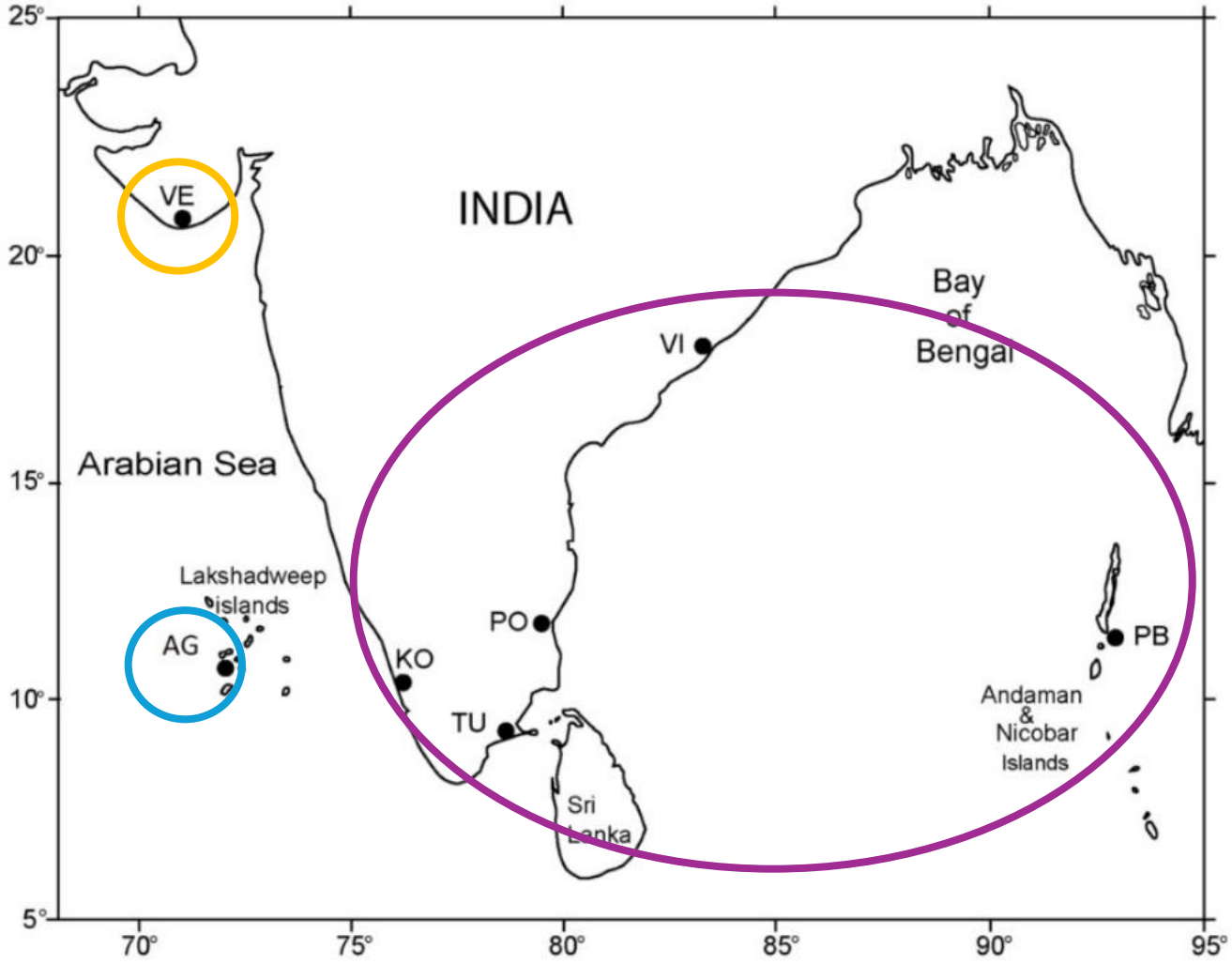




Source: Barth et al. 2017

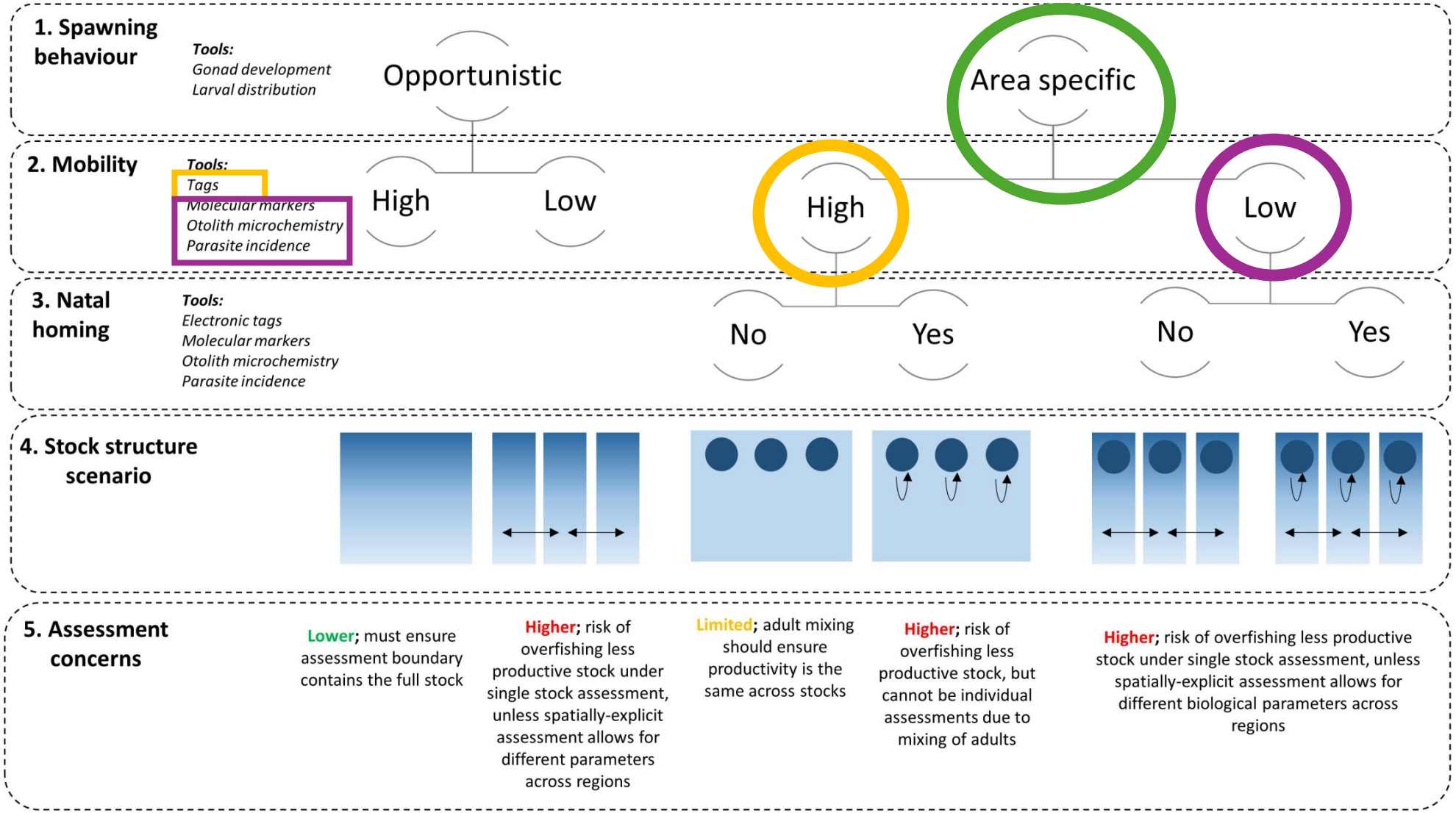
Genetics

- Minimum of 2 genetically differentiated groups of yellowfin tuna (but likely more) with different contribution north and south of the equator (Grewe et al. 2020)
- Genetic differentiation of yellowfin tuna from the Arabian Sea compared to those from the Atlantic and Indo-Pacific oceans (Barth et al. 2017)
- Significant differentiation among yellowfin tuna collected in the Arabian Sea and other areas of the north-central Indian Ocean (Kunal et al., 2013).



Source: Kunal et al. (2013)

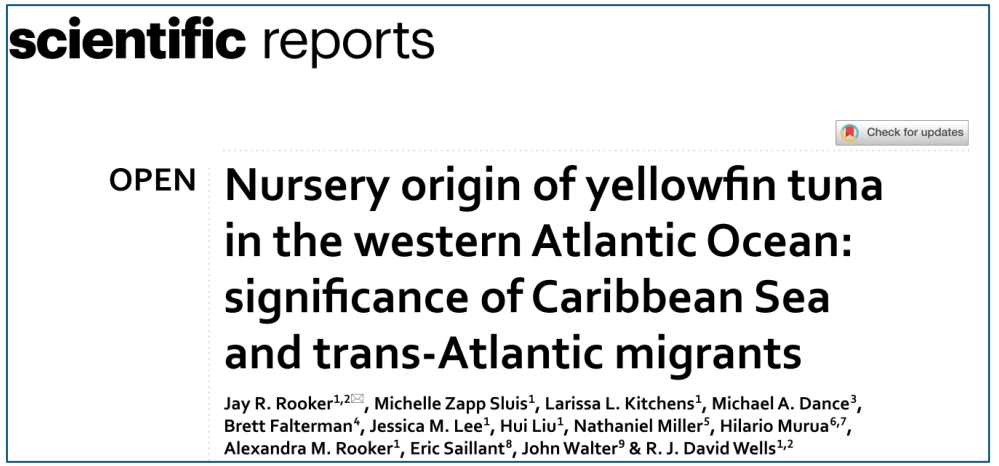
Stock Structure Scenarios



Source: Artetxe-Arrate et al. 2021; Adaptation from SPC FAME, 2019.

Natal homing

- The degree of spawning area fidelity and/or natal homing for yellowfin tuna in the Indian Ocean is unknown:
  - H.1. YFT spawn in different areas over the course of their life
  - H.2. Spawn in the same area throughout their life (i.e., spawning site fidelity)
- Behavioral differences? E.g. Resident vs migrants
- Need of spawning adults captured during spawning seasons in spawning areas (tagging, genetics, otolith chemistry), larvae and YOY as reference samples (genetics, otolith chemistry)



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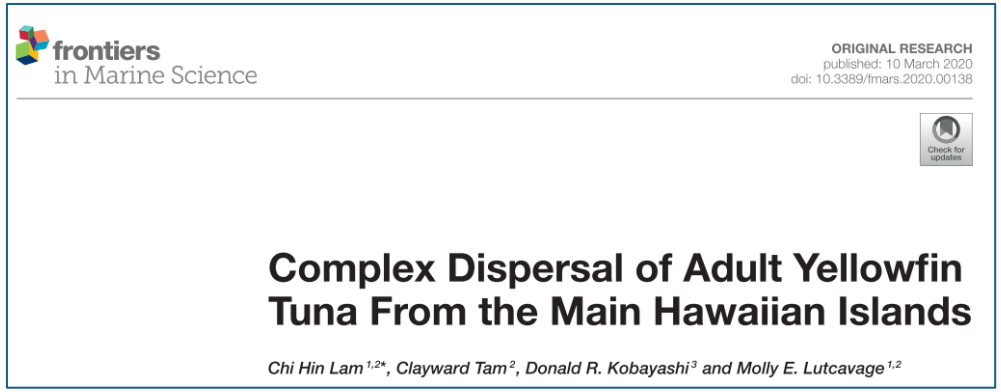
Nursery origin of yellowfin tuna in the western Atlantic Ocean: significance of Caribbean Sea and trans-Atlantic migrants

Jay R. Rooker[1,2]✉, Michelle Zapp Sluis[1], Larissa L. Kitchens[1], Michael A. Dance[3], Brett Falterman[4], Jessica M. Lee[1], Hui Liu[1], Nathaniel Miller[5], Hilario Murua[6,7], Alexandra M. Rooker[1], Eric Saillant[8], John Walter[9] & R. J. David Wells[1,2]



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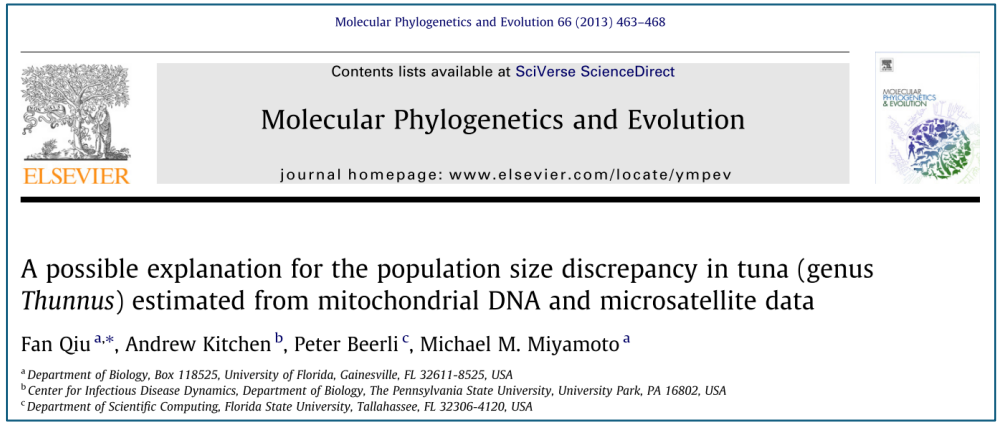
Complex Dispersal of Adult Yellowfin Tuna From the Main Hawaiian Islands

Chi Hin Lam[1,2], Clayward Tam[2], Donald R. Kobayashi[3] and Molly E. Lutcavage[1,2]*



Molecular Phylogenetics and Evolution 66 (2013) 463–468

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ELSEVIER

A possible explanation for the population size discrepancy in tuna (genus *Thunnus*) estimated from mitochondrial DNA and microsatellite data

Fan Qiu[a,*], Andrew Kitchen[b], Peter Beerli[c], Michael M. Miyamoto[a]

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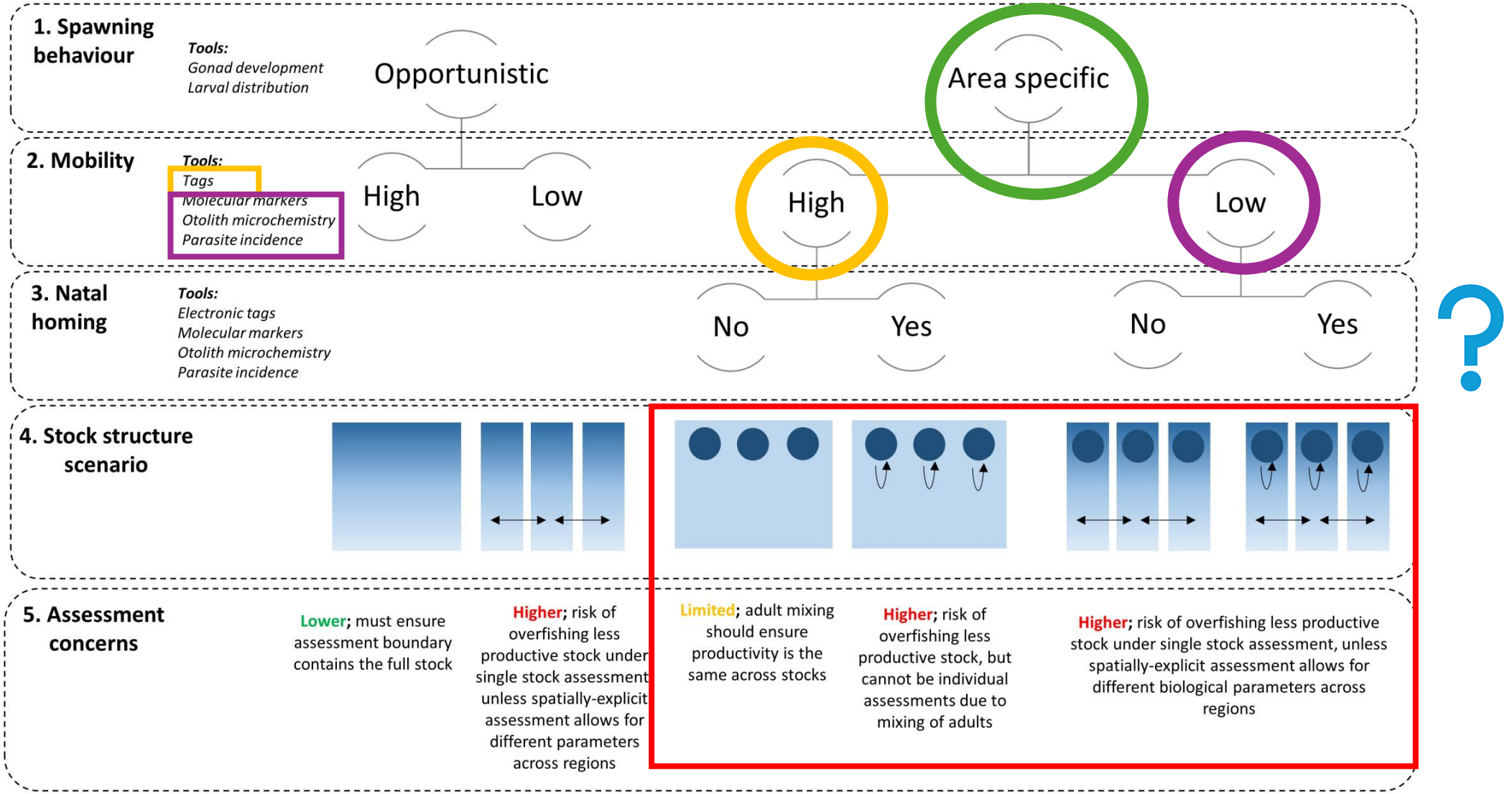
[b] Center for Infectious Disease Dynamics, Department of Biology, The Pennsylvania State University, University Park, PA 16802, USA
[c] Department of Scientific Computing, Florida State University, Tallahassee, FL 32306-4120, USA

Stock Structure Scenarios



Source: Artetxe-Arrate et al. 2021; Adaptation from SPC FAME, 2019.

SUMMARY

- Low recovery rates in the east for tuna tagged in the west
- Otolith microchemistry data suggest low east to west connectivity
- Parasite data suggest low connectivity between central and eastern Indian Ocean
- Discrete genetic groups with different presence in the north and the south of the equator
- Arabian Sea seems genetically different from other areas in the Indian Ocean